PRELIMINARY RESULTS ON THE POST-IMPACT HYDROTHERMAL ALTERATION IN THE YAXCOPOIL-1 HOLE, CHICXULUB IMPACT STRUCTURE, MEXICO. Lukas Zurcher and David A. Kring, Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson, Arizona USA 85721. (lzurcher@geo.arizona.edu)

Introduction: The results presented here are part of an investigation into the evolution of hydrothermal events associated with the Chicxulub impactites in Yucatan, Mexico. The study focuses on alteration products in core samples recovered from the Yaxcopoil-1 drill hole, which is located some 60 kilometers from the center of the impact structure. This research contributes to the growing knowledge-base of post-impact hydrothermal systems [e.g. 1, 2] and their importance as potential life-originating environments [3]. Macroscopic and petrographic descriptions, as well as preliminary electron microprobe and RAMAN spectrometry analyses, thus far, indicate a systematic spatial and temporal distribution of hydrothermal products in the Yaxcopoil-1 core.

Protolith: To understand the sequence of replacement by hydrothermal products it was necessary to assess the original mineralogy of the altered protolith. At the Yaxcopoil-1 site, a green melt unit is composed of microcrystalline plagioclase, clinopyroxene, K feldspar, and a silicate phase, potentially glass, that has been pervasively replaced by phyllosilicates. Clinopyroxenes contain a small fraction of sodium (Aeg_{1-3}), and plagioclases are relatively calcium-rich (An_{50}). This mineralogy points to a slightly alkaline andesitic composition for the original rock. A single electron microprobe analysis of edenite suggests that subordinate amphibole was also present. The green melt is covered by breccias with abundant melt clasts of similar textures and mineralogy, as well as target clasts of variable composition.

Fractures: In addition to mineralogies susceptible to hydrothermal replacement, high permeability in the host rock plays an important role in providing the necessary channels and traps for hydrothermal fluids. For this purpose, an estimate of fracture densities was carried out from visual inspection of scanned color images of the Yaxcopoil-1 core. Only those fractures filled with alteration products (i.e. veins and stockworks) were considered in the analysis. The results are presented on a log scale in Figure 1 as percentages of total rock (combined vein width in cms per line-m of core). Fracture densities vary from 0 to 70%. With exception of the reworked suevite-suevite interface (~808 m), the highest densities occur about lithologic contacts. Correspondingly, contact zones also exhibit the most prominent hydrothermal brecciation.

Hydrothermal Alteration: Replacement textures and vein cross-cutting relations from samples YAX-1_876.46, YAX-1_863.51, YAX-1_861.40, YAX-1_857.65, YAX-1_841.32, YAX-1_836.34, YAX-1_832.83, and YAX-1_829.56 were used to deduce a preliminary time-sequence of deposition of hydrothermal minerals. Since the samples are representative of different depths along the Yaxcopoil-1 hole, an assessment of the space distribution of alteration associations was also possible.

Early Ca-Na Metasomatism. An electron microprobe analysis of a hedenbergite grain, and numerous microprobe analyses of microcrystalline plagioclase confirmed the presence of limited Ca-Mg-Fe- and widespread Ca-Na-exchange, respectively (see Figure 1). Calc-silicate and plagioclase replacement (albitization) are processes that typically occur in a high temperature (350-550°C) hydrothermal environment. Early magnetite occurs as replacement halos around variably albitized microcrystalline plagioclase and quartz xenocrysts in the impact melt and breccias.

Early Low-Temperature Alteration. Discrete grains of anatase and vein-controlled gaylussite were identified with a RAMAN spectrometric survey in the melt unit and overlying suevitic breccia (see Figure 1). Anatase and gaylussite were deposited relatively early because they are cut by later K feldspar and chlorite-clay veins. They are common products in low temperature metamorphic, and saline lake environments, respectively.

K Metasomatism. Early Ca-Na alteration is cut by K feldspar-magnetite-calcite veins in the impact melt unit. The overlying breccia units exhibit more extensive but diffuse K feldspar (adularia?) and magnetite replacement fronts, which partially flood breccia matrix and surround microcrystalline unaltered and albitized feldspar in melt clasts. This alteration style has been recognized as a product of percolation of saline brines at low temperatures [4]. However, a microprobe analysis confirmed the presence of secondary biotite ($Phl_{63}Ann_{24}Sid_{13}$) (see Figure 1), which points to a higher temperature environment.

Late Low-Temperature Alteration: Under the microscope, an abundant fibrous mineral occurs mainly as partial replacement of the impact melt groundmass, as veins, and as vesicle linings. This mineral was identified as chlorite with RAMAN spectrometry. However, chlorite is in turn pervasively replaced by clay, making assessment of cross-cutting relations and original abundance very difficult. Much of the chlorite could be associated with the early Ca-Na metasomatic stage. Chlorite-(magnetite)-calcite veins toward the base of the impact melt sheet cut K feldspar-calcite-bearing fractures. Toward the top of the melt unit, the time-sequence is partially inverted. There, calcite veins with or without chlorite centers are more dominant. In the overlying breccia units, much of the calcite was introduced during and after the K feldspar metasomatic stage. K feldspar-calcite fronts both overprint and are cut by chlorite veins. Under the microscope, three different phyllosilicate phases are apparent. Electron microprobe analyses indicate that these phases are water-saturated. However, positive identification of their mineralogies with the electron microprobe or RAMAN spectrometry has, thus far, not been successful. Analytical results point to the presence of very fine-grained mineral or amorphous mixtures. The latest hydrothermal stage is represented by open-space fillings and linings of calcite. In addition to calcite, vugs lined with barite-(chalcopyrite) and calcite-(molybdenite) also occur at the base of the suevitic breccia (~860m) and suevite (~822m) units, respectively (see Figure 1). These latest minerals are the only sulfur-bearing constituents identified thus far in the studied section, and propose that sulfur was leached and transported from elsewhere.

Discussion: Preliminary interpretation of the hydrothermal environment at the Yaxcopoil-1 site suggests that Ca-Na metasomatism was induced by impact-driven heat, and the resulting convection of pre-existing formation brines [i.e. 5]. K metasomatism, in contrast, could have been formed by downward percolation of alkaline saline brines, such as seawater, shortly thereafter or at a later time. Low temperature alteration associations containing calcite and phyllosilicates, similarly, could be the product of diagenetic processes [i.e. 6]. Ongoing research should further constrain the nature of the hydrothermal evolution at the Yaxcopoil-1 drilling site.

References: [1] McCarville P. and Crossey L. J. (1996) *GSA SP 302*, 347-376. [2] Osinski G. R. et al. (2001) *M&PS, 36,* 731-745. [3] Kring D.A. (2000) *LPI Contrib. 1053*, 106-107. [4] Ennis D. J. et al. (2000) *Chem. Geol., 167 2-4,* 285-312. [5] Johnson D. A. and Barton M. D. (2000) *SEG GS 32*, 145-162. [6] Arkai P. (2002) *MSA RMG 46,* 463-478.

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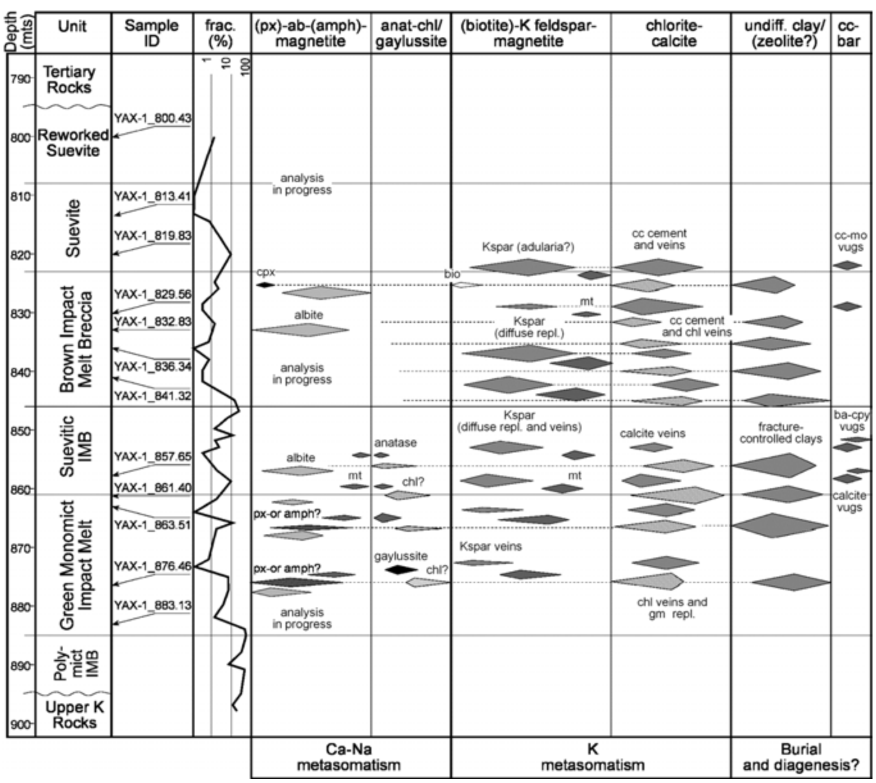

Figure 1: Time-space alteration sequence at YAX-1